NICARAGUA

ARAP

Agriculture Reconstruction Assistance Program

<u>BUSINESS COURSES FOR IDENTIFICATION OF ALTERNATIVE TILAPIA PRODUCTION SYSTEMS</u>

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Background

The combination of stabilization of natural stocks of fish; the growing demand for high quality, edible fishery products, not only for taste but for health purposes; the development of efficient and cost-effective culture technologies; the availability of trained culture professionals; and the expansion of tilapia production and marketing infrastructure, have all worked together to make the fish tilapia one of the most rapidly expanding productions of culture aquatic animals. Tropical countries, where tilapia perform best, have a distinct advantage over temperate regions in the culture of tilapia, particularly Central American countries, with close proximity to the huge markets of the USA and Canada. Imports to the USA fresh and frozen tilapia increased by 55% from 1997 to 1998, and continues to increase at a high annual rate, reaching 21,534 MT. Consumption of tilapia in the USA is expected to expand 20% annually, with fastest growth in fresh fillets, the primary product of Latin American exports to the USA. Leaders in the production of farmed tilapia in the Latin American region include Ecuador (now the leader in production and volume exported to the USA), Costa Rica and Honduras. Nicaragua, despite a greater natural resource base (land, water) than either of its Central American neighbors, has not yet invested significantly in this new alternative of food production. Tilapia farming, as well as the farming of other tropical aquatic species, offers to Nicaragua a fresh opportunity for investors and producers to gain a foothold in what is claimed to be the fastest growing sub-sector within the agricultural sector of many countries.

The Consultancy

As part of ARAP's program in Nicaragua to assist local non-governmental associations, producer associations and cooperatives active in the agricultural sector located in the areas affected by Hurricane Mitch, this consultancy focused mainly on the identification of fish (tilapia) production systems and the divulgation of this information through conferences to potential tilapia farmers of Mitch areas.

The specific objectives of the consultancy were:

1. Identify alternative tilapia production systems.
2. Present advantages and disadvantages of different tilapia production systems on the basis of specific regional considerations in Hurricane Mitch-affected areas.
3. Suggest best models for tilapia production in different Hurricane Mitch-affected areas based on required capital investments and suitability of natural and human resources present.
4. . Divulge regional-specific conclusions through business-focused seminars for potential tilapia farmers.

To accomplish the above objectives, the following deliverables were established:

1. Three one-day business courses/seminars/conferences, focusing on suitable tilapia production systems identified for each of the areas: another in Chinandega for the Leon/Chinandega region, one in Esteli, for the Esteli/Matagalpa and central highlands region, and a third in Managua, for the coastal regions of the Pacific and Atlantic lowlands.
2. A written report consolidating the consultant's conclusions as to the suitable models for the specific Hurricane Mitch regions.

FIELD TRIPS TO TARGET ZONES

To become familiar first-hand with the characteristics of the target zones and opinions of principal players in the development of these regions, a series of interviews were conducted, by telephone and by visits to representative areas in target zones. Below is a summary of findings:

<u>Esteli/Matagalpa and central highlands region:</u>

6-7 July: I traveled to the Esteli and Matagalpa areas to view aquaculture activities, interview persons involved with aquaculture development in one way or another, and obtain data and photographs of examples of existing and potential aquaculture facilities. In Esteli I met and toured the Esteli area with Noel Castillo, a recent aquaculture/ agribusiness graduate from Univ. of Mobile-Latin American campus, presently involved with his family in diverse agricultural (dairy/beef production) and road/earth construction activities. He has interest in constructing earthen farm ponds, oxidation lagoons, etc., as well as some day entering into commercial fish seed production. Shortly after graduation Noel spent several months in Israel on a training scholarship in fish production.

Visited were the following facilities/institutions: 1) ECAGE (Escuela Catolica Agricola Ganadera de Esteli), main campus, located 17 km from Esteli: directed by Dr. Francisco Fiallos. The day we visited ECAGE all main staff were on holiday (National Teachers' Day) but the Operations Chief, Claudio Gutierrez (ex- Operations Chief at UM-LAC) showed us the animal production facilities. Of prominence there were rabbit production (based on many varieties of pure strains), earthworm/compost production, purebred swine production. No methane generation was employed to treat and utilize animal manures (to make methane gas and residue for fertilizing aquaculture ponds), nor water reservoir(s) to receive and treat animal waste.
2) ECAGE Training Center, located 5 km from Esteli, on an asphalt highway, built with funding from Spanish entities, inaugurated in 1999. It serves as a dual-purpose facility to: a) train ECAGE students in aquaculture, b) train local farmers in diverse agricultural and aquacultural practices. The Center is well equipped with a dormitory, cafeteria, administrative offices, training rooms, and the following aquaculture infrastructure: several earthen ponds, several concrete tanks, and 2 animal corrals (located next to excavated lagoon, for demonstrating integrated agri-aquaculture). The site appears ideal for practical training and applied research in diverse aquaculture activities (mass seed production, grow-out, polyculture, agri-aquaculture, etc.). Well water and electricity make the site complete with all necessary inputs to permit entering into, when considered appropriate, higher intensity culture alternatives (e.g., aeration, water exchange, water recirculation, aquaponics). Soil at the site is high in clay, ideal for preventing water loss through seepage. It was noted that the drain for the large pond was much higher than pond bottom, making impossible its complete drainage by gravity, and drain structures were absent from small earthen ponds.

Just outside Esteli is the municipal sewage treatment complex, consisting in earthen ponds, well constructed, with potential for some type of aquaculture production. Also noted were several natural ponds, probably constructed to hold water for cattle, of potential for extensive aquaculture production.

The local CARE office was visited in Esteli, where Salomon Baltodano, advisor of the fish pond projects in the San Juan de Limay area, was interviewed. Lots of interest is shown by local farmers involved in the project. Over-population, due to uncontrolled reproduction of tilapia in the ponds, seems to prevent them from harvesting fish of an attractive market size. MAG-FOR has been involved with them to certify that the fish product is safe for sale to the market.

Matagalpa: dinner was shared with three residents of Matagalpa, two of whom are involved in aquaculture (one in shrimp farming, the other in pond construction). They all felt that there was a great need for fish culture in the local area in order to supply fresh fish to the municipal market, as well as to provide quality protein to farm workers, especially laborers working to harvest coffee when in season. They related successful experiences of friends who set up rudimentary tilapia production in earthen ponds and in converted coffee processing tanks for local sale or consumption by their families and/or farm workers. They also related unsuccessful experiences with untrained and inexperienced tilapia investors in the region.
San Ramon, Matagalpa: visit coffee farm owned by Ricardo Oliu, to view an irrigation reservoir, about 0.5 Ha water area impounded, with no fish culture use at present.

Leon/Chinandega Region:
12-13 July: 1) Interview with Francisco Rodriguez, in Leon, Director of Farralon Aquaculture, a new marine shrimp hatchery nearing completion in Poneloya, Leon, and with in-depth experience in marine shrimp and tilapia grow-out in ponds. He expressed his ideas on how to efficiently get the tilapia farming industry to advance solidly, both in freshwater as well as brackishwater (shrimp farms mainly). His main concerns were the lack of financial support from the banking sector for either existing or re-engineered tilapia production systems, as well as technical assistance for inexperienced producers, and a marketing system for the product. He is convinced of the wealth of resources and opportunity that Nicaragua represents in the farming of tilapia, particularly for export.
2) Interview with Lic. Raul Baldizon , Leon, and visit of his farm near Poseltega, Leon. Lic. Baldizon, a lawyer, owns and operates his son a 200 mz. sugar cane farm, where they have built two earthen ponds (2,000 m2 each) for tilapia culture. Water is supplied to the fish ponds by gravity from an older irrigation reservoir (1-1.5 Ha) built to supply water to the sugar cane sections. The reservoir is supplied with a good quality stream that originates just 1 km away. A water-impelled generator supplies 4 KW of electrical energy to the nearby house and farm structures. At least double the amount of electricity presently generated could be generated with a larger generation system. The ponds were constructed with a small tractor-pulled hydraulic scraper, at apparently a very low cost. Neither pond has adequate drainage: water drains from the surface only. Both are severely underutilized as fish culture ponds, although tilapia have been stocked. All-males were supposedly stocked but enough females were included in the stocking that now the ponds appear to have excessive populations. They desperately seek technical assistance to effectively exploit what is a well-constructed system, and hope to expand to new ponds they plan to construct in the near future.
3) Nicaragua Camaronera (Ingenio San Antonio), Chichigalpa: the shrimp farm manager, Lic. Leonel Santana, was interviewed on his recall of Nicaragua Camaronera's experience

with converting 12 (approximately 1 Ha in size each) freshwater sugar irrigation ponds for the culture of red tilapia, imported from Choluteca, Honduras. None of the staff working on the system at that time (about 1 year prior to Hurricane Mitch, which carried the fish populations away, and virtually destroyed the project). He recalled many problems with management of the ponds, which were not in one single place, but rather widely dispersed, requiring several hours before the supervisor could complete a round of inspection. Robbery was reported to plague all the units, guarded at night by a single guard. Severe mortalities occurred, the cause for which was not explained. With the loss of fish during Mitch the tilapia project was abandoned, and there is no apparent interest to resume the culture.

POTENTIAL FOR AQUACULTURE IN THE HURRICANE MITCH-AFFECTED REGIONS.

An analysis of existing aquaculture or infrastructure potentially feasible for conversion to aquaculture was made for each of the three Hurricane Mitch-affected regions, with the objective to provide an indication of their possible application (i.e., level of culture) an relative abundance of such infrastructure in each region. Following is information that addresses these issues:

(A) a description of production systems (culture levels);

(B) an analysis of relative abundance of existing aquaculture infrastructure or infrastructure with potential for construction of aquaculture (fish) units;

(C) and examples of existing infrastructure with fish culture potential found in Hurricane Mitch-affected regions of Nicaragua..

A. AQUACULTURE GRO-W-OUT PRODUCTION SYSTEMS:

Eight levels of culture intensity and their characterization.

Level 1, Extensive:

- Minimum in sophistication, use of inputs (seed, nutrients water), cost, yield; little control over water quality and nutrification of water.
- Culture unit: earthen pond (preferably drainable), cattle watering/irrigation basins, lagoon, lakes, reservoirs.
- Applicablility of system: land is inexpensive, not apt for significant income generation, low construction costs.
- Disadvantages: complete harvest unlikely, mixed sizes, off-flavors.

Nutrients:	Natural food organisms
Stocking density (fish/m2):	0.1 to 0.2 (= 1,000 to 2,000/ha)
Water exchange (% water volume/day):	None
Aeration:	None
Yield (kg/ha/crop):	300-700

Level 2: Semi-Intensive

- Intermediate in sophistication, as well as use of inputs (seed, nutrients, water), cost and yield; moderate control over water quality and nutrification of water.

- Culture unit: earthen pond, controlled water draining/filling, integrated land animal (manure production) + fish
- Applicablility of system: good quality feed ingredients not available, or expensive; good quality fertilizers, agricultural by-products available;; inexpensive labor.

Nutrients:	Natural food organisms + fertilizer (inorganic, organic), agricultural by-products
Stocking density (fish/m2):	0.5 to 2
Water exchange (% water volume/day):	0 to 10%
Aeration:	None
Yield (kg/ha/crop):	inorganic fertilizer: 1,500-2,500 organic fertilizer: 2,000-6,000 agricultural by-products: 4,000-8,000

Levels 3 to 8: Intensive

- Maximum in sophistication, as well as use of inputs (seed, nutrients, water), cost and yield; high degree control over water quality and nutrification of water.

Level 3: Intensive (Emergency aeration)

- Culture unit: earthen pond, controlled water draining/filling
- Applicablility of system: good quality feed ingredients available, not expensive.
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Nutrients:	Natural food organisms + high quality pelleted feed
Stocking density (fish/m2):	1 to 3
Water exchange (% water volume/day):	As needed
Aeration:	When D.O. is <10% of saturation
Yield (kg/ha/crop):	5,000-10,000

Level 4: Intensive (Continuous aeration)

- Culture unit: earthen pond, controlled water draining/filling.
- Applicablility of system: high land costs, high labor costs; good quality feed ingredients available, not expensive.
- Disadvantage: high ammonia levels produced.
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Nutrients:	Natural food organisms (minor), high quality, complete pelleted feed
Stocking density (fish/m2):	1 to 3
Water exchange (% water volume/day):	none
Aeration:	When D.O. is <20% of saturation
Yield (kg/ha/crop):	8,000-15,000

Level 5: Intensive (Continuous aeration/partial water exchange)

- Culture unit: small culture units: earthen ponds, < 1 ha, concrete tanks, 100-400 m2, controlled water draining/filling, center drain.
- Applicablility of system: high land costs, high labor costs; water supply not abundant; good quality feed ingredients available, not expensive.
- Disadvantage: high ammonia levels produced.

Nutrients:	High quality, complete pelleted feed
Stocking density (fish/m2):	5 to 10
Water exchange (% water volume/day):	200 to 300
Aeration:	Continuous
Yield (kg/ha/crop):	20,000-100,000

Level 6: Intensive (Continuous water exchange (raceway))

- Culture unit: small culture units, earthen ponds or concrete tanks, 100-400 m2, with center drain,
- Applicablility of system: where high water flow available at no or low pumping costs; good quality feed ingredients available, not expensive.
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Nutrients:	High quality, extruded (floating) feed
Stocking density (fish/m3):	70 to 200
Water exchange (% water volume/hour):	Continuous (100-300) (= 2,400 to 7,200%/day)
Aeration:	Usually none
Yield (kg/m3/crop):	70 to 200

Level 7: Intensive (Cages)

- Culture unit: lagoons, lakes, estuaries, reservoirs, ocean, canals.
- Applicablility of system: impounded or flowing water available, good qualiity; land costs high.
- May be consuidered applicable for Extensive culture, where algal and natural foods are abundant, and where cage cost is relatively low.

Nutrients:	Extensive/semi-extensive: supplementary feeds; Intensive: high quality, pelleted/extruded feed
Stocking density (fish/m3): (depending on current & water quality)	Small cage (<5 m3): 200 to 600 Large cage (>5 m3): 50 to 100
Water exchange (% water volume/day):	Natural exchange: variable
Aeration:	Normally none
Yield (kg/m3/crop):	Small cage (<5 m3): up to 300 Large cage (>5 m3): > 50

Level 8: Intensive (Water recirculation, Water reuse)

- Culture unit: small scale units: concrete/plastic tanks; aquaponics (fish culture + hydroponics: to remove excess nutrients produced in fish units

- Applicablility of system: low temperature zoners; water supply scarce (20 up to 500 m3 water used/1,000 kg fish produced); energy (pumping) costs reasonable; land costs high;
- Disadvantages: high capital and operating costs; high need for technical expertise; high risk of fish mortality; low oxygen, high ammonia, nitrite, carbon dioxide, nutrient levels (hence need for aeration and constant water recirculation through mechanical and biological filtration; need to sell product as high value.

Nutrients:	High quality, pelleted/extruded feed
Stocking density (fish/m3):	50 to 100
Water exchange (% water volume/day):	<1 to 10
Aeration:	Continuous: air or pure oxygen
Yield (kg/m3/crop):	20 to 50

B. Relative Abundance of Existing Infrastructure (E) or Infrastructure with Potential for Construction (P) of Aquaculture (Fish) Units in the Hurricane Mitch-affected Regions of Nicaragua

Infrastructure (1)	Applicable Culture Level (2)	Esteli/Matagalpa & Central Highlands	Leon/Chinandega	Pacific &Atlantic Coastal Lowlands
Aquaculture ponds (fish)	EXT, SINT, INT	E: fair number, small scale P: high, at intermediate altitudes	E: fair number, small scale P: high	E: fair number, small scale P: high
Aquaculture ponds (marine shrimp)	EXT, SINT, INT	E: low (one site, small scale, river shrimp) P: fair (many cool zones)	E: large number P: high	E: small number P: high
Animal watering ponds	EXT, SINT (cages)	E: numerous P: high	E: numerous P: high	E: numerous P: high
Coffee processing plants (not in use)	EXT, SINT, INT	E: numerous P: high	E: few P: low	E: fair P: fair
Animal slaughter plants	EXT, SINT	E: fair P: fair	E: fair P: high	E: fair P: high
Milk/cheese processing plants	EXT, SINT	E: fair P: fair	E: fair P: fair	E: fair P: fair
Municipal waste treatment	EXT, SINT	E: low number P: fair/good	E: low number P: fair/good	E: low number P: fair/good
Seafood processing plants	EXT, SINT	E: none P: low	E: numerous P: high	E: fair, on both coasts P: high
Paddy rice (fish in canals)	EXT, SINT	E: numerous P: high	E: fair P: good	E: fair P: good
Irrigation lagoons/systems	EXT, SINT, INT	E: fair P: high	E: numerous P: high	E: fair P: high
	EXT, SINT, INT	E: P:	E: P:	E: P:

1) Processing plants (coffee, milk, animal slaughter, seafood, etc.): refers to infrastructure (water tanks, water delivery systems), waste residue treatment units, and/or high quality nutrients are available for nutrifying aquaculture units.
2) EXT = extensive culture level, SINT = semi-intensive; INT = intensive;

C. Examples of Existing Infrastructure with Fish Culture Potential Found in Hurricane Mitch-affected Regions of Nicaragua:
Aquaculture ponds (fish): San Juan de Limay, Posoltega, Matagalpa, Esteli, Ciudad Dario
Aquaculture ponds (marine shrimp): Estero Real, Estero Padre Ramos, Poneloya
Animal watering ponds: virtually in all parts of the regions
Coffee processing plants (not in use): Matalgalpa, all medium to high altitude zones of northern Nicaragua.
Animal slaughter plants: Chinandega, Leon, Esteli, Matagalpa, all major municipalities.
Milk/cheese processing plants: Boaco, Leon, Chinandega, in most regions
Municipal waste treatment: Matagalpa (new system), other major municipalities (in future)
Seafood processing plants: Chinandega, El Viejo
Flooded rice(fish in canals): Esteli, Sebaco, Leon, Chinandega
Irrigation lagoons/systems: rice (San Francisco Libre), sugar cane (Posoltega), vegetables (Esteli, Sebaco)

Labor Force Needs: Unskilled and Skilled Laborers and Technicians:

Although not required in excessively high numbers, even in sophisticated commercial fish farms, the anticipated short-term demand for skilled and non-skilled laborers and middle-level technicians is likely to be filled with no trouble in all three regions, given that specific skill and continuing training is provided to them. Senior-level technical and business management with expertise on commercial fish farms is, however, likely to be scarce, except that one can consider recruiting and, to some extent, retraining skilled marine shrimp farm managers and technicians to handle and manage a fish farm.

TILAPIA BUSINESS CONFERENCES

Three one-day conferences were prepared by the Consultant for prospective investors and agricultural producers interested in the farming of tilapia. The first was held on 12 July in Esteli, the second on 17 July in Chinandega, and the third on 28 July in Managua.

Invitation to attend the conferences was extended by Chemonics to individual producers and producer organizations, bank officials, NGOs, and others with potential interest in tilapia farming.

The number of participants at each conference were as follows: 45 in Esteli, 25 in Chinandega, and 85 in Managua.

Each conference began approximately 9AM and ended around 4PM. Lunch was provided to all attendees at each of the conferences.

The topics covered for each conference, followed the general outline below:
Why the interest in aquaculture? World shortages in fishery products, rising demand for fishery products, predictability of output from aquaculture,
Distribution and biology of the Tilapia

Original and modern day distribution, nutrition/feeding, reproduction, physical, chemical and biological parameter tolerances, life history, growth.
Characteristic of tilapia as a cultured fish (advantages vs. disadvantages)
History of its culture: From 1930s to present day, focusing on Latin America.
Importance of Tilapia: from the viewpoints of the producer (and the fish) vs. viewpoint of the consumer

Marketing of Tilapia: Domestic, export, product forms, prices,
Processing and quality control: off flavor problems, HACCP & ISO 9000 quality criteria
Culture models: Extensive, semi-intensive, intensive systems
Costs and earnings with selected production models
Ideas to obtain success in marketing/exporting Tilapia

In the Managua conference the general manager of a private processor and exporter of fish and shellfish and leading exporter of tilapia in Nicaragua, Mr. Patrick Bolaños of NICANOR, complemented the sessions with an hour-long presentation on tilapia buying, processing and export experiences, practices and guidelines for producers in Nicaragua.

MODEL FOR CALCULATING REQUIREMENTS FOR SEED, POND AREA AND POTENTIAL FOR PRODUCTION OF AN EXISTING FARM:

A model was developed for demonstrating how to simply calculate basic requirements (infrastructure, operation, costs, income) for establishing a fish (tilapia) farm, given a pre-established export goal and area available for developing the farm.

CASE/EXERCISE: Calculation of Infrastructure and Operational Requirements, Costs and Net Income From Production of Tilapia on a Cattle Farm

GOAL: Produce 1000 kg of 5-7 (= 6) oz. tilapia fillets to export weekly.
OBJECTIVE: Determine requirements for seed and land area, and potential for an existing cattle farm to produce tilapia.

Criteria for design of the fish farm:
1. Production based on 2 phases:
1) Rearing of fingerlings (NURS): 4 - 20 g; 2) Grow-out (G-O): 20 - 1,362 g;
3. Area and number of NURS and G-O pond to be determined.
3. Area available on the farm for aquaculture: 100 ha.
(with 20% of that area for dikes, canals, access roads) = 80 ha.
4. Fish species: Nile tilapia (Oreochromis niloticus).
5. Dress-out, whole, live to fillet: 25%.
6. Harvests: Partial with seine, total draining pond.
7. Stocking, operation and harvest parameters for each culture phase:

Culture Phase	Maximum Capacity (kg/ha)	Growth (g/fish/d)	Avg. fish wt. (g)		Survival (%)
			Stock.	Harvest	
NURS	10,000	0.5	4	20	90%
G-O	20,000	5	20	1,362	92%

A To determine:
1. Number and total weight of fish to stock and harvest in each phase:
2. Number and total of area of culture units for each culture phase.
3. Weekly and annual potential to produce tilapia fillets with available area.

SOLUTIONS

1. Number and total weight of fish to stock and harvest in each phase:
Basis: Size of live fish required to harvest:
{(2 x 6 onz filLets/fish) x (28.375 g/oz))/25% dress-out =1,362 g/fish

Culture Phase	NO. FISH STOCK	HARVEST	WT/ LIVE FISH (KG) STOCK	HARVEST	AREA REQ./ POND (M2)	NO. DAYS/ PHAASE
NURS	3,547	3,192	14.2	63.8	63.8	32.0
G-O	3,192	2,937	63.8	4,000.0	2,000.0	268.4

2. Number and total of area of culture units for each culture phase.

	NURS	(rounded to)	G-O	(rounded to)	TOTAL
Area/pond (m2)	63.8		2000		
Total no. ponds req.(1)	4.6	5	38.3	39	44
Total area req. (m2) (2)		319		78,000	78,319

(1) Total no. ponds req.(1). = (No. days/phase)/(duration of each cycle: 7 days)
(2) Total area req. = Total no. ponds x area per pond.
3. Weekly and annual potential to produce tilapia fillets with available area.
Land area available: 80 Ha = 800,000 m2

Production potential = (800,000 m2)/(78,319 m2 for each 1,000 kg fillet produced/week)
= 10,214.6 kg 6 oz tilapia fillet each week
= 531,159 kg 6 oz tilapia fillet per year

Gross Value (based on $US3.00/lb (= $US6.60/kg) fillet, FOB-Miami = $US 3,505,649/yr

INVESTMENT MODELS FOR TILAPIA FARMING

Several models were developed to illustrate the infrastructure and operational needs, costs, earnings and relative feasibility for farming Tilapia in the Hurricane Mitch affected regions of Nicaragua.

In the models large fillets (5-7 oz.) have been chosen as the final product due to the increasingly greater competition and lower prices for smaller fillets in the international market from new production entering the market system.

A. INVESTMENT MODEL: Tilapia in Two Newly Constructed 5-Ha Semi-Intensive Earthen Ponds.

GOAL: export fillets of tilapia

PRODUCTION PARAMETERS (export fillet)

NURSERY	Response
Stocking density (no. early fingerlings/m2)	25
Avg. harvest size, live (g)	50.0
Feed Conversion Efficiency	1.8
Survival (%)	75%
Yield (kg fish/Ha-cycle)	9,375
Production (kg/cycle)	12,500
No. days in cycle	30

Area required/cycle (Ha.)	**1.33**
No. Nursery ponds	**1**

GROW-OUT	
Grow-out area (Ha)	**10**
No. Grow-out ponds	**2**
Stocking density (no. late fingerlings/m2))	**5.0**
Fillet size ((# oz./fillet)	**6.0**
Avg. harvest size, live (g)	**1,135**
Growth rate (g/d)	**5.0**
Fillet dress-out (%)	**30%**
Feed Conversion Efficiency	**1.5**
Survival (%)	**80%**
Yield (kg fish/Ha-cycle)	**8,000**
Production (kg fillets/cycle)	**24,000**
No. days in cycle	**217**
No. cycles/yr	**1.7**
Production fillets (kg/yr)	**40,369**

CALCULATION OF DISTANCES, CROSS-SECTION AREAS, VOLUME AND COSTS FOR EARTH-MOVING TO CONSTRUCT 1 NURSERY POND (NURS. 1.33 Ha) AND TWO 5 HA GROW-OUT PONDS (G-O 10 Ha).

Section	Type Structure Fill: dikes	Vehi-cular? (Yes/No)	DIMENSIONS CROWN (m)	HEIGHT (m)	SLOPE INT	EXT	BASE (m)	VOLUME FILL (m3/LM)	DIS-- TANCE (mL)	TOTAL VOLUME (m3)	TOTAL VOLUME +10% (M3)	COS M3 (US
A-1	NURS, water supply end	No	2.00	1.80	2.00	2.00	9.20	10.08	54	544.3	598.8	
A-2	G-O #1, water supply end	No	2.00	1.80	2.00	2.00	9.20	10.08	200	2,016.0	2,217.6	
A-3	G-O #2, water supply end	No	2.00	1.80	2.00	2.00	9.20	10.08	200	2,016.0	2,217.6	
B-1	NURS, side	No	2.00	1.80	2.00	2.00	9.20	10.08	250	2,520.0	2,772.0	
B-2	NURS/G-O#1. common side	No	2.00	1.80	2.00	2.00	9.20	10.08	250	2,520.0	2,772.0	
B-2	G-O#1/G-O #2. common side	No	2.00	1.80	2.00	2.00	9.20	10.08	250	2,520.0	2,772.0	
B-4	G-O #2, side	No	2.00	1.80	2.00	2.00	9.20	10.08	250	2,520.0	2,772.0	
C-1	NURS, harvest end	Yes	3.50	1.80	2.00	2.00	10.70	12.78	54	690.1	759.1	
C-2	G-O #1, harvest end	Yes	3.50	1.80	2.00	2.00	10.70	12.78	200	2,556.0	2,811.6	
C-3	G-O #2, harvest end	Yes	3.50	1.80	2.00	2.00	10.70	12.78	200	2,556.0	2,811.6	
								Sub-total	**movimiento de tierra**		22,504.3	m3

STRUCTURES AND COSTS FOR WATER CONTROL TO CONSTRUCT ONE NURSERY POND (NURS. 1.33 Ha) AND TWO 5-HA GROW-OUT PONDS (G-O 10 Ha).

TYPE OF STRUCTURE	UNIT	No./ Ponds	Cost/ Unit. (US$)	Total Cost (US$)
Water supply, NURS	Ea	1	200	200
Water drain/harvest, NURS	Ea	1	300	300
Water supply, G-O# 1 & 2	Ea	4	250	1,000
Water drain/harvest, G-O# 1 & 2	Ea	2	300	600
Water drain, G-O# 1 & 2	Ea	2	400	800
	sub-total water control structures			**$2,900**

FINANCIAL PARAMETERS: 1 NURSERY POND (NURS. 1.33 Ha) AND TWO 5-Ha GROW-OUT PONDS (G-O 10 Ha). Semi-intensive

INCOME	
Fillet exports, 5-7 onz ($US/lb)	**$3.00**
Total Annual Income	**$266,433**

COSTS

Capital Investment (C.I.)	
Pre-project costs	**500**
Earthwork	**33,756**
Road surface cover	**1,271**
Water control structures	**2,900**
Buildings, misc. structures	**1,000**
Equipment	**2,000**
Total Capital Investment	**41,426**

Variable Costs (V.C.)	Unit	Quantity/ Yr	Unit Price (US$)	Total Cost Per yr.
Seed (fingerlings)	ea	1,121,352	0.02	22,427
Laborers: full-time	person-yr	2	5,720.00	11,440
Laborers: temporary workers	person-day	16	80.00	1,280
Fertilizer, limestone	100 lb	20	8.00	160
Feed: Nursery	100 lb	833	15.00	12,489
Feed: Grow-out	100 lb	4,441	15.00	66,608
Fuel	gal	500	2.31	1,154
Lubricants (5% x fuel)				58
Ice (1 lb/lb fish)	100 lb	2,960	3.00	8,881
Domestic shipping	lb. whole fish	296,037	0.02	5,921
Processing/packing (fillet export)	lb. fillet	88,811	0.40	35,524
Iintn'l. shipping (fillet export)	lb. fillet	88,811	0.80	71,049
Maintenance (% Fixed Investment)			5%	2,071
		sub-total C.V.		**$239,062**
Return Above Variable Costs				**$27,371**

Fixed Costs (20% x Capital Investment)	**$8,286**
Total Annual Costs (T. C.)	**$247,348**
Net Earnings (Losses)	**$19,085**

Break-even Point Scenarios

SCENARIO A: No salary included in costs

Break-even point: Price (to cover V.C.) (US$/lb fillet)	**$2.69**	
Break-even point: Price (to cover T.C.) (US$/lb fillet))	**$2.79**	
Break-even point: Yield (to cover V.C.) (kg fillet)/yr)	**36,222**	= **8.97** Ha G-O pond area
Break-even point: Yield (to cover T.C.) (kg fillet)/yr)	**37,477**	= **9.28** Ha G-O pond area

Conclusion: two 5-ha Grow-out ponds is slightly more than sufficient production area to be profitable with fish market prices and costs as assumed above, and not paying salary to owner.

SCENARIO B: Yearly salary expected by owner: $19,000

Break-even point: Price (to cover V.C.) (US$/lb fillet)	**$2.91**	
Break-even point: Price (to cover T.C.) (US$/lb fillet)	**$3.00**	
Break-even point: Yield (to cover V.C.) (kg fillet)/yr)	**39,100**	**= 9.7** Ha G-O pond area
Break-even point: Yield (to cover T.C.) (kg fillet)/yr)	**40,356**	**= 10.0** Ha G-O pond area

Conclusion: two 5-ha Grow-out ponds is sufficient production area to be profitable with fish market prices and costs as assumed above, and still pay expected salary of $19,000/yr to owner.

SCENARIO C: Yearly salary expected by owner: $30,000

Break-even point: Price (to cover V.C.) (US$/lb fillet)	**$3.03**	
Break-even point: Price (to cover T.C.) (US$/lb fillet)	**$3.12**	
Break-even point: Yield (to cover V.C.) (kg fillet)/yr)	**40,767**	**= 10.1** Ha G-O pond area
Break-even point: Yield (to cover T.C.) (kg fillet)/yr)	**42,022**	**= 10.4** Ha G-O pond area

Conclusion: a total of 10.4 ha Grow-out ponds is the required area to be profitable with fish market price at $3.12/lb fillet and costs as assumed above, and pay expected salary of $30,000/yr to owner.

B. INVESTMENT MODEL: Tilapia Production in Rehabilitated Ponds (Seed Production) and Irrigation Reservoir (Cage Grow-out).

GOAL: market fresh, whole tilapia to local market

Assumptions:

1. Existing infrastructure: Two existing earthen ponds (Ponds A & B), 2,000 m2 each, functional as seed production units for tilapia, with minor modifications;

One 1-Ha (10,000 m2) irrigation reservoir, functional as grow-out unit for floating cages, and water source for seed production ponds, with no improvements required.

2. Production: based on one harvest per week of two 2-m3 cage per week.
3. Product Sales: in local urban market, fresh, whole, on ice.
4. Cage yield: 300 kg/2-m3 cage
5. Length culture cycle: 180 days
6. No. crops/cage per yr: 2
7. Annual Production: 300 kg/2 m3 cage/week x 52 weeks/yr = 68,640 lb/yr
8. Annual Sales (@ ₡8.00/lb whole)= $ 40,676

INCOME	
Whole fish (Cordoba/lb)	**₡ 8.00**
Total Annual Income (US$)	**$ 40,676**

CAPITAL INVESTMENT (CI)

Unit	Function	Require-ments	No. Required	Cost/unit (US$)	Total Cost (US$)
Pond A (2,000 m2)	Separate Broodstock	Hapa, 1 m3	2	$ 80	$ 160
Pond A (2,000 m2)	Spawning	Hapa, 2 m3	2	$ 120	$ 240
Pond B (2,000 m2)	Sex Reversion (0-0.5 g)	Hapa, 2 m3	2	$ 120	$ 240
Pond B (2,000 m2)	Nursery (0.5-50 g)	Seine, 50 mL	1	$ 200	$ 200
Reservoir (10,000 m2)	Grow-out (50-790 g)	Cage, 2 m3	52	$ 120	$ 6,240
Modify Pond Drain Structures	($/pond):		2	$ 250	$ 500
				Sub-total CI	**$ 7,580**

VARIABLE COSTS (VC)

Hand nets, various sizes	8	$ 10	$ 80
Feed (FCA 1.8) (100 lb)	686.4	$ 15	$18,533
Ice (1 lb ice/1 lb tilapia) (100 lb)	686	$ 2	$ 1,373
Laborers ($/pers-yr)	3	$ 1,300	$ 3,900
Domestic shipping (lb. whole fish)	68,640	$ 0.02	$ 1,373
Technical Supervision (50% full-time)	0.5	$ 6,500	$ 3,250
		Sub-total VC	**$ 28,508**

Return Above Variable Costs	**$ 12,167**
Fixed Costs (20% x Capital Investment)	**$ 1,516**
Total Annual Costs (T. C.)	**$ 30,024**
Net Earnings (Losses)	**$ 10,651**

Conclusion: a total of 52 two-m3 grow-out cages harvested weekly for local sales is profitable with fish market price at 8.00 Cordobas/lb whole fish and costs as assumed above, leaving a return $10.651/yr to owner.

RECOMMENDATIONS

1. Technical, administrative and financial advisory assistance.

Provide immediate technical, as well as administrative and financial advisory assistance, and specific training on the same, to individual/group producers committed to either beginning a new tilapia production system or adapting/modifying existing infrastructure apt for tilapia farming. The areas of high priority include:

1) Site selection;
2) Culture system design (culture units expected to be mainly earthen ponds, converting existing watering ponds, irrigation canals/lagoons, residue treatment ponds, etc);
3) Mass seed production (focusing on all-male fingerlings by androgen sex-reversal and hand-sexing fingerlings, possibly later hybridization);
4) Grow-out production and post-harvest strategies and methodologies, including seed stocking, fertilization, feeding, pond bottom and water treatment and management, harvesting, product transportation to processing plant/market (focusing on live and iced product); post-harvest methods (to include HACCP/ISO-based principles of quality control, purging off-flavor),
5) Production cycle technical and financial analysis; record-keeping (by hand and by computer),

2. Basic and advanced training programs.

Sponsor/provide the financial means for implementing basic and advanced training programs for university-level instructors in aquaculture ("Train Trainers"), to serve as local/regional trainers of/advisors to developing aquaculture production groups/individuals, and to provide classroom instruction in basic (and advanced where appropriate) aquaculture courses for local/regional high schools/trade schools/university branches.

2.1. Short-range program: to serve immediate need of prospective and actual aquaculture producers and instructional centers; focus on all areas mentioned in (1) above.

2.2. Medium- to –long-range program: in addition to topics as (1) above, to include: project engineering (design of a new project, project expansion, integration of agricultural enterprises (animal and/or land crop production) with aquaculture, aquatic health maintenance and disease prevention; overall farm management; preparing a loan proposal; marketing aquaculture products; frozen product handling and processing; strategies and methodologies for exporting aquatic products;

Instructional centers with existing aquaculture infrastructure and production experience include ECAGE, Esteli; the "La Calera" aquaculture station, UNA, Managua; Ave Maria College of the Americas; San Marcos, Carazo; and the freshwater aquaculture station, UCA, Managua.

Recommended is linking with agricultural development projects now underway and proven to be effective (e.g., Chemonics, Winrock International), to implement aquaculture projects, especially when such an activity forms an integral part of the total farm system (water use/reuse, fertilizing crops with aquaculture effluent, fertilizing aquaculture crops with animal manures, using waste/swampy land for ponds, etc.) .

3. Tilapia Production Demonstration Centers

The establishment of regional centers where culture models for seed production and grow-out are constructed, operated and demonstrated will accelerate and consolidate the development and adaptation of appropriate culture technology. At least one well-equipped center in each of the two major Mitch-affected zones, Leon/Chinandega and Esteli/Matagalpa, and possibly others of less magnitude (e.g., shore of Lake Apanas for cage-based culture), would facilitate and make more effective the learning/adaptation process. In addition to demonstration, these centers will serve ideally to develop improved alternative models and methodologies, as well as effectively serve as applied research centers. Excellent candidate sites would be the Baldizon sugar-cane farm near Poseltega, the ECAGR Aquaculture Station in Esteli, and alongside Lago de Apanas. Each of these sites has on-going commercial agricultural production activities (small animal, vegetable, sugar cane, etc), hence the probability for the successful integration of aquaculture in the overall agricultural context is likely to increase.

4. **Reinforcement of tilapia breeding stocks**

For cooler, higher altitude zones (altitudes more than 600 meters above sea level or 22 C or less)) the tilapia species presently cultured massively in Nicaragua, Oreochromis niloticus, may not be the ideal species. Another tilapia species, O. aureus, formerly cultured in Nicaragua, grows well at least several degrees C below which O. niloticus ceases growing. If bringing in a pure O. aureus seed or brood stock (or hybrid red line with O. aureus genes for cool tolerance), it is strongly urged that all precautions be made to certify the stock free of pathogens, that proof (by electrophoresis or a similar acceptable technique) be shown of the purity of the stock, and on arrival a strict quarantine procedure be applied before stocking in open waters.

5. **Association of Tilapia Producers**

Strongly recommended to the provision of support (logistic, financial, leadership, training, etc) for the formation of an association of tilapia producers, and their eventual integration into the existing national aquaculture (shrimp mainly) farming association (ANDA). The purpose of such an association might include support of members and the sub-sector in general, in lobbying efforts, coordination of training efforts, coordination of external as well as internal assistance efforts; joint marketing of products, both for domestic and export sales; establishing member product quality standards, as well as control mechanisms on farms (hatcheries and grow-out), processing plants, feed mills, distribution channels,

6. Technology searching and marketing intelligence

For a small country like Nicaragua, with all the inherent limitations that may represent (lack of resources to develop and maintain employed a sufficiently adequate team of experts of diverse disciplines, funding to implement research and development efforts that are of lengthy duration of a complex and costly nature, etc.) should look where it may short-cut the development process. This may be done by looking at where to enter markets already growing, searching for and adopting cutting-edge and competitive technologies that are available. For these to result in a highly successful development program it is no necessarily dependent on a great deal of money, but rather can be so with excellent information, technology and management decision-making. For this a highly qualified team of directors/advisors to create the links to where is found the information necessary. Several avenues worth considering way is for such as

1) Linking with regional sources and managers of technical/marketing information, agri-aquacultural libraries and data bases centers (and networks); (a network presently exists for all agricultural libraries in Nicaragua);
2) Join as members of commodity support organizations, such as Global Aquaculture Alliance, World Aquaculture Society, American Tilapia Association, Tilapia Marketing Association, Asociacion Latinoamericana de Acuacultura, etc.),
3) Establish an in-country "clearinghouse" for all information relevant to the development of aquaculture in Nicaragua.

7. **Native aquatic species for aquaculture:**

To advance in the knowledge required to culture native fish, crustaceans and mollusks and to effectively include them as members of the aquaculture system, it is imperative to support research regarding the actual (or potential) adaptability of native aquatic species to culture requirements. Most all native species probably have value as food animals, in addition many are presently sought by the aquarium trade for their unique characteristics as pets (color, rareness, behaviour, reproductive habits, etc.). To mention several for their present value as food and or aquarium pets, there are the *guapotes (pando* and *tigre*), *mojarras* (many unique species), freshwater eels, freshwater prawns (river shrimp), *popoyote*, etc.

Foremost of needs to permit their regular and predictable inclusion as members of aquaculture systems is information on reproduction (seasonality of young life stages and broodstock in nature: time of year, numbers availability, location, etc.); mechanism employed in nature to induce spawning, number of eggs and fry per spawn, duration of egg and larval development, etc.); nutrition and feeding (nutritional requirements of and natural food organisms eaten by larval and juvenile stages, adult fish), growth rate under ideal environmental conditions; tolerance/adaptation of life stages to culture conditions of stress (crowding, handling, high/low levels of chemical/physical water parameters (dissolved oxygen, hydrogen sulfide, ammonia, nitrite, carbon dioxide, pH, alkalinity and hardness, temperature, salinity, etc); compatibility with other species in polyculture; disease susceptibility and response to prophylactic measures, and finally economics of culturing the species, and their marketability.

8. **Tilapia gene-types**

Give support (initial capital and medium-term operational) support for the establishment of an objectively wide selection of tilapia gene-types (purebred lines as well as hybrids), so as to be able to test out each under strict experimental control for their culture attributes (tolerance and performance at low temperatures, high salinities, extensive to intensive culture regimes, low oxygen, high ammonia/nitrite), and then have specific lines available of broodstock and or seed stock for particular farms situations. This center could be considered a "Center of Excellence" in matters of systems and policy development, as well as producer and academic training and research, regarding tilapia genetics, husbandry, species/line identification (by electrophoresis, PCR, etc.), quarantine policy,

9. Integrate aquaculture as part of irrigation systems
Focus on irrigation systems, especially rain water ponds, existing or being implemented, to integrate aquaculture as an integral part of the infrastructure and operation. This may mean re-engineering the design and possibly require additional infrastructure. In most cases at least the water delivery capital costs are already sunk and will reduce total cost to aquaculture production, and in some cases will result in reduced fertilizer costs to the crop for which the irrigation system was initially designed (as in the fertilizing/feeding of fish in temporary reservoir ponds for rice).

10. **Survey of existing water holding structures**
Identify location, size, characteristics of existing water holding structures in Nicaragua, through data either existing but not processed (e.g., latest MAG=FOR census), or by new studies. Highest in priority targets for a new study should be to encourage members of producer/marketing associations, cooperatives, as they will be more likely to collaborate through the influence of the group leaders, than individual producers.

11. **Promote integration of "water harvesting" and aquaculture**
Promote concept of "water harvesting", that is, the capture of rain water in earthen catchment basins/ponds/lagoons, for the water be used for multiple purposes: family needs, recreation, "fee fishing", animal watering, irrigation, fire fighting, and aquaculture. This is particularly crucial where ground water is now limited and/or costly, or possibly contaminated, and in arid (at least seasonably) parts of the country. This effort has already begun with the support of certain NGOs and FCR, but with little of no orientation or design to incorporate aquaculture as a high priority user of the water.